

EVALUATION OF BLASTING IN AN OPENCAST MINE

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

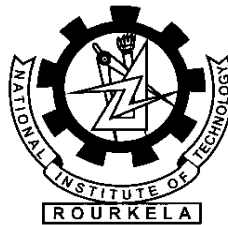
In

Mining Engineering

By

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108MN015



Department of Mining Engineering

National Institute of Technology Rourkela-769008

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Under the Guidance of

Dr. MANOJ KUMAR MISHRA



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Rourkela

CERTIFICATE

This is to certify that the thesis entitled “**EVALUATION OF BLASTING IN AN OPENCAST MINE**” submitted by **Sri Arya Pragyan** in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in this thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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Date:

Arya Pragyan

108MN015

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ABSTRACT

Fragmentation is one of the key issues in opencast blasting as properties like shape and size of rock materials are very important information for production optimization. The degree of fragmentation influences the economy of the mining process and hence the fragmentation of blasted rock forms the basis to evaluate the quality of a blast. Digital image processing technique is the latest fragmentation analysis tool. This technique has recently been proved better than the conventional methods. Those methods are also time saving and offer accurate measurement.

Wipfrag is an image analysis system for measuring size distribution for blasted or crushed rock. It was developed by Wipware, Inc. Canada. It accepts images from a variety of sources such as roving cam coders, digital camera, photographs, or digital files. It uses automatic algorithms to identify individual fragments on the image, and measures the profile areas on the blocks. It reconstructs a three-dimensional distribution using geometric probability.

In this study, 10 images from a blasted chromite muck pile were analysed through WipFrag image analysis system. Both single and merged image analysis were done and the merged image analysis was used to evaluate optimum fragmentation. Mean fragmented size of the blasted rocks has been predicted from the analysis.

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CHAPTER-1

INTRODUCTION

INTRODUCTION

1.1 GENERAL

Mining has been the second most old profession or activity undertaken by humankind for improving its habitation. The mining industry is ranked as the basic industries of early civilisation. From ancient times to the present, mining has a lot of importance in human existence. The essence of mining in extracting mineral from the earth is to drive an excavation or excavations from the surface to the mineral deposit. If the excavation is entirely open or done from the surface, it is termed as a surface mine. If the excavation is done for human entry below the earth's surface, it is called an underground mine.

To break the ore and loose it from the surrounding rock mass was the primary challenge to the early miners. The unit operations of mining are the basic steps used to produce mineral from the deposit, and the auxiliary operations that are used to support them. The steps contributing directly to mineral extraction are production operation, which constitute the production cycle of operations and the ancillary steps that support the production cycle are termed as auxiliary operations. The production cycle employs unit operations that are normally grouped into rock breakage and material handling. Breakage generally consists of drilling and blasting (Shankar, 2001).

The degree of fragmentation affects the economy of the mining process. Different characteristics of blasted rock such as fragmentation size, volume and mass are fundamental variables affecting the economics of mining operation and the decisive factors for evaluating the quality of a blast.

The properties of fragmentation such as size and shape are very important information for the optimisation of the production. Three factors control the fragment size distribution: the rock structure, the quantity of explosive and its distribution with in the rock mass.

1.2 IMPORTANCE OF BETTER FRAGMENTATION

Blasting results are generally assessed according to the ability of the mining system to cope with the resulting muck. If the blasting fragmentation is poor, then so many difficulties will arise. Some major problems due to poor fragmentation are described below

- Secondary blasting will be necessary that is a cost-additive process.
- The mucking rates gets reduced. The loading rate from a draw point is controlled by the size and looseness of the muck (Bhandari,1996). Extensive manoeuvring is required by the excavator to load large rocks and the bucket loads are usually reduced when working coarse grain.
- Poor fragmentation creates problems in handling and transport. It affects crushing and efficiency of the transportation.
- It also leads to poor milling performance. The development and growing application of semi autogenous grinding mills and fully autogenous mills put increasing emphasis on the size distribution of the ore delivered from the mine. Problems arise when the size distribution varies with time and when the proportion of fines exceeds the desirable levels (Winzer et al., 1983).

Hence a better fragmentation is desirable that would reduce all above problems.

1.3 OPTIMUM FRAGMENTATION

The rock fragmentation is optimum when it contains maximum percentage of fragments in the required range of size. The desired size is the size which is in demand and can be effectively used by the consumers without any further operation. The desired size varies from consumer to consumer, (Venkatesh,2010). Optimum fragmentation results in higher productivity, less wear and tear of the loading equipments and hence less maintenance of equipment and plant.

1.4 AIM AND OBJECTIVES OF THE PROJECT

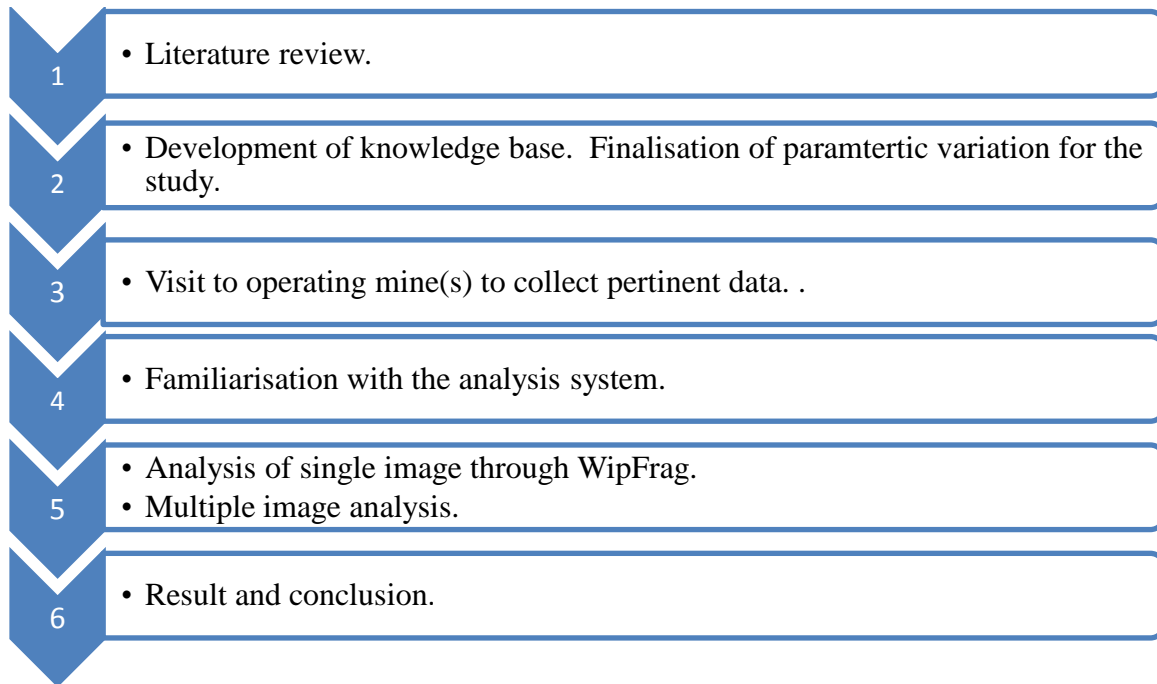
The goal of the investigation is to evaluate blasting efficiency through fragmentation. The following specific objectives are determined to achieve the goal.

- To critically review literature to obtain a background of different aspects of blast performance, in general and fragmentation, in particular.
- To view the fragmentation process and collect data.

- To study the WipFrag image analysis system.
- To analyse the data collected and find the optimum fragmentation.

1.5 METHODOLOGY

The methodology to obtain the objectives is shown in the below flow chart.



CHAPTER-2

LITERATURE REVIEW

LITERATURE REVIEW

2.1 MECHANISM OF ROCK FRAGMENTATION BY BLASTING

Various parameters like explosive parameters, blast geometry, strength of rock, geo-technical conditions affect the degree of fragmentation of rock. The blasting operation causes the rock fail due to crushing, tensile fracture, release of load, strain energy generation, shearing action, flexural rupture etc.

After an explosive is initiated, the site around the drill hole will crush and will deform plastically. The effects of an explosion can be divided into:

- The charge explodes and it is divided into high-pressure, high-temperature gases.
- The gases are applied to the borehole, which contains them. Then it creates a strain field in the rock.
- This strain field, due to its impulse nature, generates a strain wave that is propagated in the rock and damages it.
- This damage is the centre of the cracks in the rock.
- The gas pressure is reduced via the cracks and separates the rock fragments.
- The pressure of these gases applied to the face of the fragments, produces forces that propel the fragments.
- The fragments adopt a ballistic trajectory.
- In areas if the damage to the rock was insufficient to generate fragments, the strain wave continues its trajectory until it runs out of energy that dissipates by making the rock vibrate.

2.2 DIFFERENT PARAMETERS OF ROCK BREAKAGE

The parameters are divided mainly into the following: Properties of explosive, Blast geometry and charge loading parameters.

2.2.1 Explosive properties

Different properties of explosive like V.O.D, density of explosive, shock wave energy and gas pressure, volume of gas, composition of explosives, powder factor, and type of detonation, primers, nature and strength of explosives affect the rock fragmentation (Das, 2001).

2.2.2 Rock properties.

The properties of rock that affect the rock breakage or fragmentation are dip, strike, compressive strength, tensile strength, shear strength, density, elastic property, bedding plane structure, presence of geological disturbances like faults, folds, fractured ground.

2.2.3 Charge loading and blasting parameters and blast geometry.

The parameters which are included in this category are diameter and the length of shotholes and charges, stemming material and height of stemming, degree of decoupling, method and sequence of initiation, blasthole diameter, spacing and burden, distribution of explosive along the hole, loading density, angle of blast hole, number of holes in a row, number of rows, subgrade drilling, climate condition, amount of strata to be broken, requirement of shape of the excavation, factors of loading, transporting and requirement of crushing and screening etc.

2.3 STUDY OF MODELS DEVELOPED FOR EVALUATION OF ENERGY UTILISED IN FRACTURING.

Good fragmentation is a subjective matter and depends generally on the end use of the rock. The necessary degree of fragmentation also depends upon the type and size of the equipment, which is used for the subsequent handling of the fragments. Large loaders, trucks and crushers generally allow large fragments. But larger equipments are not made for handling larger fragments but for handling larger volume of materials. The ideally fragmented rock is that which needs no further treatment after blast and the desired size can be different if the blasted rock is to be transported to the dump area than if it has to be sent to the crusher.

McKenzie (1966) found, that the efficiency of all the subsystems is dependent on the fragmentation.

Nielsen (1983) determined the optimum actual specific charge (kg/m^3) considering the influence on different subsystems of mining in an iron ore mine of Norway.

There are several models developed for evaluation of energy utilised in fracturing. The oldest theory of **Rittinger (1867)** states that energy consumed in size reduction is proportional to the reduction in particle size. Hence,

$$W=K_R(1/D_1-1/D_2)$$

Where W =energy input for size reduction;

D_1 =initial particle size;

D_2 =final particle size; and

K_R =the Rittinger's constant.

Kick (1885), on the other hand, concludes that breaking energy is related to the total strain energy required by the particles to bring them to the point of failure and, hence, is a function of volume.

Bond (1952) indicates in his “Third law” that the particle must first be strained to the breaking point (volume dependent) and then new surface area is created during the failure (area dependent).

Oka and Majima (1969) showed that all these laws of Rittinger, Bond and Kick can be best described in the below equation.

$$W=K_1 (P^{-6/B}-F^{-6/B})$$

Where F =feed parameter;

P =Product diameter

K_1 =constant

B =infinite(Kick's law)

=6 (Rittinger's law)

=12(Bond's law)

Farmer et al. (1991) relate the difference in the pre and post blast specific surface area (SSA , m^{-1}), which is surface area per unit volume of rock, as a measure of explosive energy utilisation.

$$G_B=W_0 (SSA_2-SSA_1)^n$$

Where SSA_1 and SSA_2 are the original and final specific surface areas of rock;

n is a constant exponent.

W_0 is a complex variable affected by rock joints.

The above expression is based on various comminution equations, such as Kick's (1885) law and Bond's (1952) theory.

It is evident from the above literature that when the explosive energy utilised in blasting is high, the product becomes finer. But only explosive energy does not govern the the product size but also the initial size of the rock which is to be fragmented. In widely jointed rocks, as the average block size is more, so more explosive energy should be utilised to obtain the desired product size. Whereas, in thinly bedded rocks, the explosive energy requirement would be less if similar size of the product is to be obtained. In openly jointed rock mass, the rock fragments get liberated from the rock mass instead of being fragmented. It is evident that

the stress wave is responsible for such liberation and the gas pressure can be poorly utilised to extend the fractures created by the stress wave.

2.4 THE KUZ-RAM FRAGMENTATION MODEL

Various models have been put forward over the years, attempting to predict the size distribution resulting from particular blast designs. The approaches fall into two broad camps.

- Empirical modelling, which infers finer fragmentation from higher energy input, and
- Mechanistic modelling, which considers the physics of detonation and the process of energy transfer in well-defined rock for specific blast layouts, deriving the whole range of blasting results.

The mechanistic approach is able to illustrate the effect of individual mechanisms in a better way than empirical models. Due to limited scale, difficulty in collecting adequate data about detonation, it becomes difficult to apply it frequently. It requires greater or lesser degrees of empiricism, so is not necessarily more accurate. For all practical purposes, the empirical models are the ones used for daily blast design, and the present author published a scheme as the Kuz–Ram model in the 1980s (Cunningham 1983 & 1987). The adapted Kuznetsov equation

$$X_m = AK^{-0.8}Q^{1/6}(115/RWS)^{19/20}$$

Where X_m = mean particle size, cm;

A = rock factor [it varies between 0.8 and 22, depending on hardness and structure – this is a critical parameter];

K = powder factor, kg explosive per cubic metre of rock;

Q = mass of explosive in the hole, kg;

RWS = weight strength relative to ANFO,

The adapted Rosin–Rammler equation

$$R_x = \exp [-0.693(x/x_m)^n]$$

Where R_x = mass fraction retained on screen opening x;

n = uniformity index, usually between 0.7 and 2

2.4.1 Parameters not taken into account

The primary assumption in empirical fragmentation modelling is that increased energy levels result in reduced fragmentation across the whole range of sizes, from oversize to fines. Although this is generally valid, but not necessarily applicable to real situations. Some of the other factors that may override the expected relationship include:

- Rock properties and structure (variation, relationship to drilling pattern, dominance of Jointing).
- Blast dimensions (number of holes per row and number of rows).
- Bench dimensions (bench height versus stemming and sub drilling).
- Timing between holes, and precision of the timing.
- Detonation behaviour, in particular detonation velocity (VOD).
- Decking with air, water and stemming.
- Edge effects from the six borders of the blast, each conditioned by previous blasting .
- Geological influences.

Thus, unless these parameters are catered for, it is possible for a model to be seriously wrong in its estimation of blasting fragmentation. Assessing and dealing with the whole range of inputs is the essence of blast engineering.

2.5 IMPORTANCE OF JOINTS AND FRACTURES ON THE DEGREE OF FRAGMENTATION

Chakraborty et al. (1994) found the joint orientations can considerably influence the average fragment size and shape.

Pal Roy and Dhar (1996) suggested a fragmentation prediction scale based on joint orientation with respect to bench face.

Hagan (1995) concludes that the results of rock blasting are affected more by rock properties than by any other variables. He also states that as the mean spacing between the joints, fissures or cracks decreases, and the importance of rock material strength decreases while that of rock mass strength increases. He also opines that in a rock mass with widely spaced joints, the blasts are required to create many new cracks. In a closely fissured rock mass, on the other hand, generation of new cracks is not needed and the fragmentation is achieved by explosion gas pressure which opens the joints to transform a large rock mass into several loose blocks. He again comments that the blasting efficiency is affected to a lesser degree by the internal friction, grain size, and porosity compared to rock strength.

Jurgensen and Chung (1987) and Singh (1991) state that the blast results are influenced by the overall formational strength in a direct way.

2.6 DIFFERENT IMAGE ANALYSIS SYSTEMS

Digital image processing using different software and hardware is the latest fragmentation tool. It has replaced the conventional methods like visual analysis, photographic, photogrammetry, and boulder count and sieve analysis technique. The conventional methods possess inherent problems. Digital image processing method comprises of image capturing of muck pile, scaling and image, filtering the image, segmentation of image, binary image manipulation, measurement and stereo metric interpretation. The method is quick and very accurate.

Research works have been carried out all over the world in developing image analysis systems. Several countries have developed their own image analysis systems. Some of these systems are:

- IPACS
- TUCIPS
- FRAGSCAN
- CIAS
- GoldSize
- WipFrag
- SPLIT
- Power Sieve
- Fragalyst

Although all the systems claim that they are suitable for rock fragmentation analysis, limited field experiments have been conducted so far to check the validity of the results.

Liu and Tran (1996) revealed that the results of fragmentation determined by three different image analysis systems were not the same.

In India mostly WipFrag and Fragalyst are used for analysis of fragmentation. To compare the output from both the software an experiment was done by **Sudhakar et al (2003)** where they compared the output of fragmentation analysis by three methods, namely WipFrag, Fragalyst and manual. The fragmentation size distribution curves for all the 10 photographs determined by all the three methods are compared. The mean fragmentation size obtained by three methods differed from each other and is not consistently higher or lower for a particular method. The uniformity index determined by the Fragalyst was greater than 3, which shows to very uniform distribution, which is not applicable to a blasted muck pile (**Cunningham, 1983**). WipFrag showed a uniformity index of 1.5, which is expected. The maximum size of fragmentation at 100% passing determined by Fragalyst was smaller than the other two methods which showed that Fragalyst had underestimated the range of fragmentation. Then the merged results were found in this study. The merging facility was there in WipFrag and Fragalyst. In case of manual method, all the individual results of 10 photographs were combined and mass passing percentage at various sieve sizes were found. The size distribution obtained from manual and WipFrag was similar, but Fragalyst gave a coarser result. The Rosin-Rammler curves corresponding to the measured distribution were found out and the deviation of D_{50} from the adjusted Rosin-Rammler curve is about 26% for WipFrag, 107% for Fragalyst and 24% for manual analysis. This indicates that Fragalyst is the least accurate with respect to fines content and WipFrag has a better analysis than Fragalyst.

CHAPTER-3

FIELD VISIT AND DATA COLLECTION

3 FIELD VISIT AND DATA COLLECTION

One important objective of the investigation is to collect pertinent data. So a local chromite mine was visited frequently and different parameters that affect the blasting was properly studied. They are

- Geology of the rock
- Rock properties
- Blasting pattern
- Spacing
- Burden
- Powder factor
- Blast hole dia,length.
- Explosive type

After studying those basic parameters, different images from different angle of view of the blasted muck pile were taken.

The chromite deposit occurs as discontinuous bands, lenses and pockets in the serpentinised dunite peridotite. The mine visited comes under Boula-Nuasahi Complex belt and in this region the chromite body is well exposed in the mines at the central part and confined to the altered dunite peridotite. These bands have a NW-SE to NNW-SSE STRIKE with moderately easterly dip and an average width of 5 meter. These discontinuous bands as well as the lences of chrome ore occurring to the north and south have been affected by shearing and faulting during post- consolidation stage. In the chromite mine visited, for data collection, v type blasting pattern was followed with hole depth of 6.5m. the spacing and burden were 3 and 2.5 m respectively. PowergelC explosive was used with a powder factor of 2.8-2.9 kg.

3.1 IMAGE TAKING INSTRUMENT

A digital camera (make: Kodak) which features 8.2 mega pixel with 3x optical zoom was used to take the image of blasted muck pile. While taking the images, two calibrated scales of 1 m each were used for measuring the scaling factor while analysing through the software and also for the tilt option. A no of images were taken from different distances from the pile with different angle of view. And later 10 samples were selected for the analysis. Some samples are given here



Figure 3.1 Image of sample1



Figure3.2 Image of sample2

3.2 DATA ANALYSIS PROGRAMME:

3.2.1 WipFrag

WipFrag is an image analysis system for sizing materials such as blasted or crushed rock (Palangio et. al., 1985). It has also been used to measure other materials, such as ammonium nitrate prills, glass beads, and zinc concentrates. From its inception about 10 years ago, WipFrag and its predecessor WIEP have been designed to take full advantage of the flexibility of general purpose microcomputers (in contrast to purpose designed image analysing computers, which being designed for metallurgical or medical use place a number of undesirable constraints on the use in mining and quarrying). This flexibility is apparent at image input, processing, and output stages of analysis.

3.2.1 Algorithm

It uses automatic algorithms to identify individual blocks, and create outline “net”, using state of the art edge detection. If desired or necessary, manual intervention (editing of the image net) can be used to improve its fidelity. WipFrag measures the 2-D net and reconstructs a 3-D distribution using principles of geometric probability (Maerz, 1996). A “missing fines” correction based on empirical calibrations, can be used, if appropriate. Alternatively, the WipFrag zoom-merge mode allows the combination of results either from several images of the same scale (“merging”) which is necessary for reliable estimation of large blocks, or the combination of results from several images at different magnification (“zoommerging”, Morley et. al, 1996) for accurate estimation of fines or for system calibration.

3.2.3 Methodology

- image processing

Image processing is used to transform the image rock fragments into a binary image consisting of a net of block outlines.

- **Block Identification**

The delineation of blocks in WipFrag involves the identification of block edges. This is done in a two stage process. The first stage uses several conventional images

Processing techniques, including the use of thresholding and gradient operators. The operators detect the faint shadows between adjacent blocks, and work best on clean images with lightly textured rock surfaces. The second stage uses a number of reconstruction techniques to further delineate blocks that are only partly outlined during the first stage. These include both knowledge based and arbitrary reconstruction techniques, to complete the net.

- **Edge Detection Variables (EDV)**

For each of the image processing stages, parameters called Edge Detection Variables (EDV) are accessible to the user, to optimize the edge detection process. The user has the choice of adjusting individual variables to optimize one stage of the process, or selecting one of nine preset combinations of EDV. These combinations are arranged in sequence to produce more or fewer edges, depending on the nature of the image. Thus selecting more edges will reduce the number of missing edges in a given image, while selecting fewer edges will reduce the number of false edges in that image.

- **Editing to improve fidelity of the net**

When improved accuracy is required, the fidelity of the net can be increased by manual editing. A set of interactive editing tools, to draw lines and polylines, erase lines, or erase areas, can be used to quickly remove false edges and draw missing edges to complete the net. The net is normally displayed as an overlay on the original rock images, so the fidelity of the net can at all times be evaluated by the user.

3.2.4 Modes of analysis

There are three methods of analysis that can be employed when using WipFrag, depending on the relative accuracy required, and the time and resources available. Since WipFrag uses geometric probability theory to unfold a 3-D distribution (Maerz, 1996), there are sometimes smaller particles “missing” in individual images. These small fragments are not visible either because they are too small to be resolved or are hidden behind larger particles (washed down by rain or dust control watering). Because the proportion of these “missing fines” is highly variable and difficult to predict, one of the following solutions is used.

- **Image analysis**

Having identified a net of fragment outlines, WipFrag proceeds with the analysis portion of the measurement. This involves a 2 dimensional measurement on the image, reconstruction of a 3 dimensional distribution and the production of graphical output.

- Measurement of Fragment Areas

In the final operation on the digital image, the block profile areas and shape factors are measured on the outline net of block edges. To this point in the analysis, all operations are performed sequentially on individual digital images in the computer main memory. At any stage of the analysis, the image or net can be saved on disk for future reference (complete with information such as scaling factors) or printed out on a laser printer to provide a hardcopy for reference.

At this point the list of block profile areas is saved to a small, compact disk file. Subsequent operations can be done immediately, or later, using one or several files at a time, including merging multiple data files into a single analysis.

- Reconstruction from 2-D to 3-D

The initial step in this phase of analysis is to divide the measured two dimensional distributions into 40 size classes or “bins”. The 2-D to 3-D conversions, using principles of geometric probability (Maerz, 1996), are performed on each bin. Initially the distribution is converted into a 3-D frequency distribution, and then to a weight percent basis. Finally the distribution is converted to a cumulative weight percent distribution.

- Graphical and Other Output

WipFrag provides output in terms of graphs and hard copies of analysis results.

The user has the option of automatically accepting the default graph during the analysis, or selecting several

Options:

- Selection of graph type, either a histogram or a cumulative curve, or both.
- Selection of one or more data files to be plotted, either sequentially, or in a combined merged single graph.
- Selection of a batch mode, in which sequential graphs are cycled and printed automatically, without user intervention.
- Selection of an output log files to record the results of each analysis.
- Selection of value of rock density for the purpose of the calculation of weight.
- Selection of a calibration value for the purposes of reconstructing the Rosin-Rammler distribution, assuming calibration values have been pre-determined.

All graphs are imprinted with four labels:

- A user supplied title.
- A user supplied secondary title.
- A WipFrag identifier, copyright, and the version number and the date of analysis.
- The assigned user identifier, and the name of the data file from which the graph was generated

3.2.5 Sources of error

There are potentially three sources of significant error in all vision based granulometry systems; sampling errors, poor edge net fidelity, and missing fines.

- Sampling Errors

Sampling errors, i.e. systematic bias in the process of taking an image of the fragmentation have the potential to be the most serious of all the errors. Such errors result if the camera is pointed at a place in the muck pile where the coarse blocks or zones of fines dominate.

- Poor Delineation of Fragments

Poor delineation of individual fragments results in erroneous results. Poor delineation arises from a combination of two sources:

- Poor images, e.g. contrast too low or high, too grainy, lighting inadequate or uneven, or the size of the fragments in the image is too small.
- Highly textured rock, where shadows and/or colourings on the surface of the rocks are as prominent as the shadows between rock fragments. Poor delineation of fragments manifests itself in two ways (Eden and Franklin, 1986):

A group of fragments are mistakenly grouped together and identified as a single block. This is known as “fusion” and represents a bias toward overestimating the true size. A single fragment is mistakenly divided into two or more individual blocks. This is known as “disintegration” and represents a bias toward underestimating the true size. Experience with WipFrag has shown that in most cases this problem is not severe. The relative amounts of disintegration and fusion tend to counteract each other and typically the effect on the measures of central tendency such as the mean or D50 tends to be slight. The effect on the measures of variability, such as standard deviation or the slope of the cumulative curve, is however somewhat more pronounced. The effects of fusion and disintegration can be somewhat reduced by careful selection of the edge detection variables. The effect of fusion and disintegration can be completely eliminated by editing the net. Experience with WipFrag has shown that just a few minutes of editing per image can almost completely negate that problem of fusion and disintegration (Eden and Franklin, 1996).

- Missing Fines

Where the smallest fragments in a distribution are not delineated on the image, either because they are too small relative to the image to be resolved, or they have fallen in and behind larger fragments, there is clearly a bias towards over representing the size of the distribution. Where the distribution has a relatively narrow size range (well sorted, or poorly graded) this is normally not a problem. However, where the distribution has a relatively wider size range (poorly sorted, or well graded), typically with size differences of more than 1 order of magnitude, missing fines start affecting the measurement results. WipFrag has the ability to deal with the missing fines problem using either an empirically based calibrations or by using multiple images taken at different scales of observation.

3.2 Single analysis of images

Using WipFrag image analysis software, all the 10 images are analysed individually. The size distribution obtained from the single image analysis cannot provide the optimum size distribution as they do not represent the whole area.

3.3 Merged image analysis

The results obtained from the single image analysis cannot be conclusive as it will not cover the whole area. But if they are merged and analysis with WipFrag, then we can get the optimum size distribution and correct parameters.

CHAPTER-4

RESULT AND ANALYSIS

RESULT AND ANALYSIS

4.1 SINGLE IMAGE ANALYSIS RESULTS

Following the methodology of image analysis in WipFrag system, the results of single image from 1 to 10 are given with the images. The image analysis shows the size distribution. The different notations shown in the image analysis curve are described below.

D_n : Nominal diameter, or equivalent spherical diameter, i.e. the diameter of a sphere with the same volume as that computed for the fragment.

D_{10} : Percentile sizes. For example D_{10} is the ten-percentile, the value of D_e for which 10% by weight of the sample is finer and 90% coarser. In terms of sieving, D_{10} is the size of sieve opening through which 10% by weight of the sample would pass.

D_{50} : The Median or 50-percentile, the value of D_n for which half the sample weight is finer and half coarser.

Mean: Arithmetic mean (average) fragment size, equal to the sum of all equivalent spherical diameters divided by the total number of particles [D_{av} (m)]

Mode: Most common sized particle, the geometric mean D_n size class interval for the class containing the greatest number of net elements (fragments) [D_n (m)]

N: Rosin-Rammler Uniformity Coefficient, equal to the slope of the Rosin-Rammler straight line fitted to the data in log-log co-ordinates.

X_c : Characteristic Size, the intercept of the Rosin-Rammler straight line fitted to the WipFrag D_n data in log-log co-ordinates. This is equivalent to the $D_{63.2}$.



Figure 4.1 Photograph of rock pile sample1

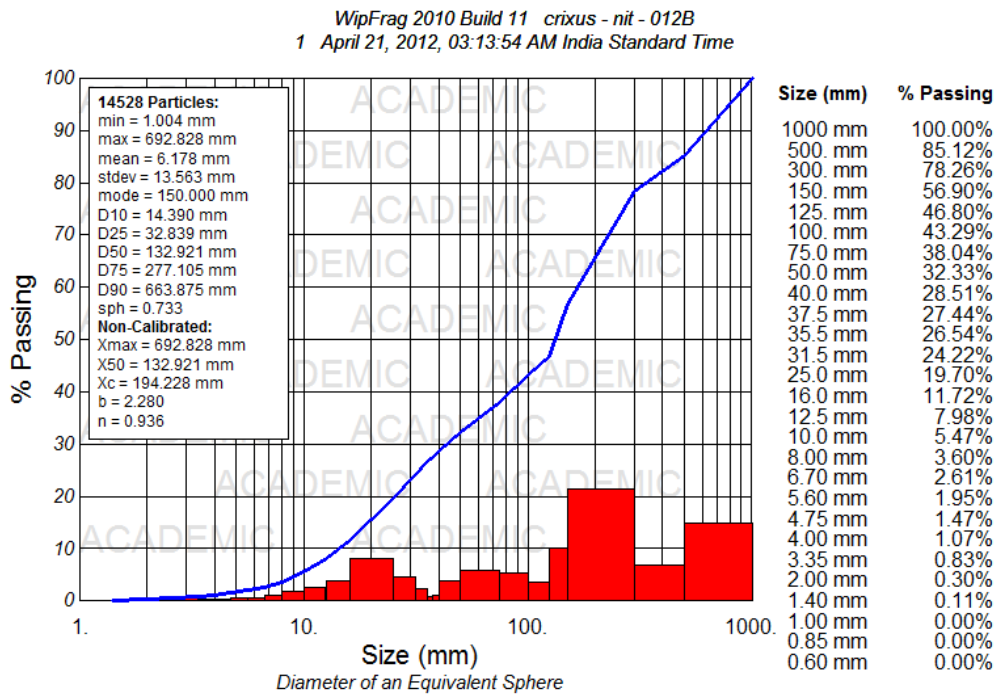


Figure4.2 Size distribution obtained from sample1



Figure4.3 Photograph of rock pile sample2

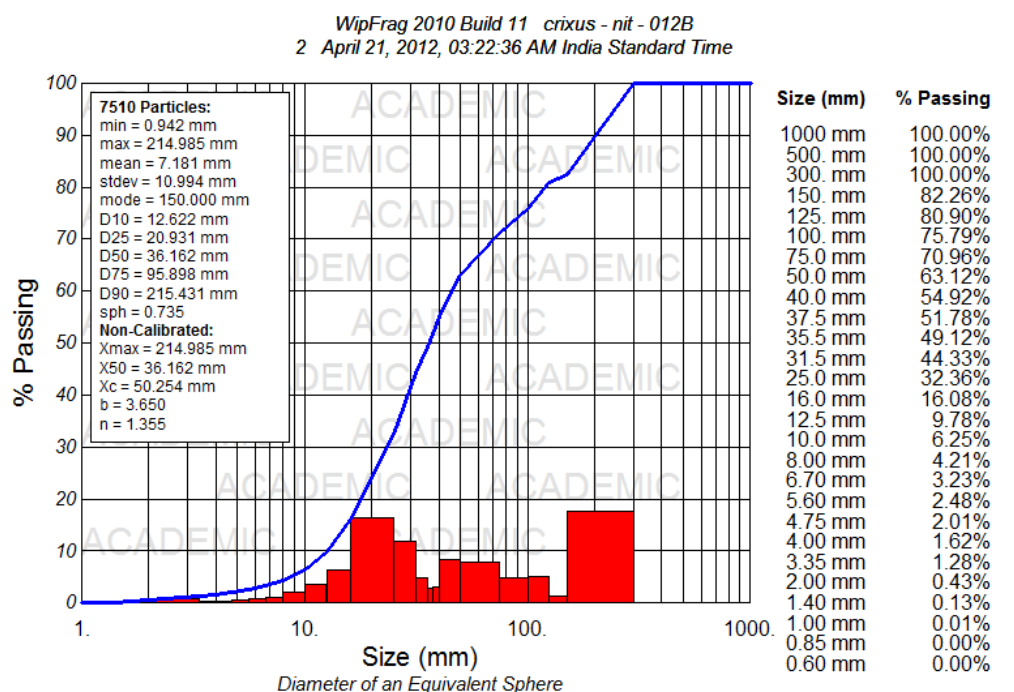


Figure4.4 Size distribution obtained from rock pile sample 2



Figure4.5 Photograph of rock pile sample3

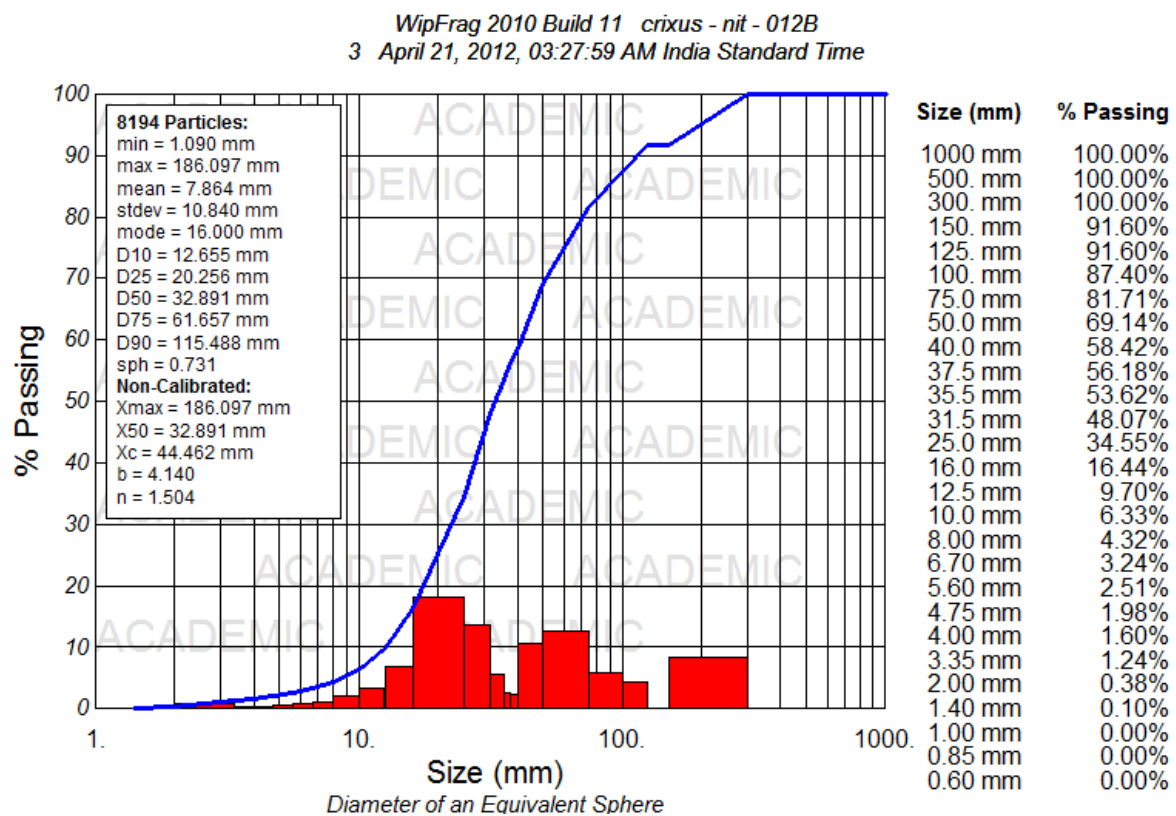


Figure 4.6 Size distribution obtained from rock pile sample 3



Figure4.7 Photograph of rock pile sample4

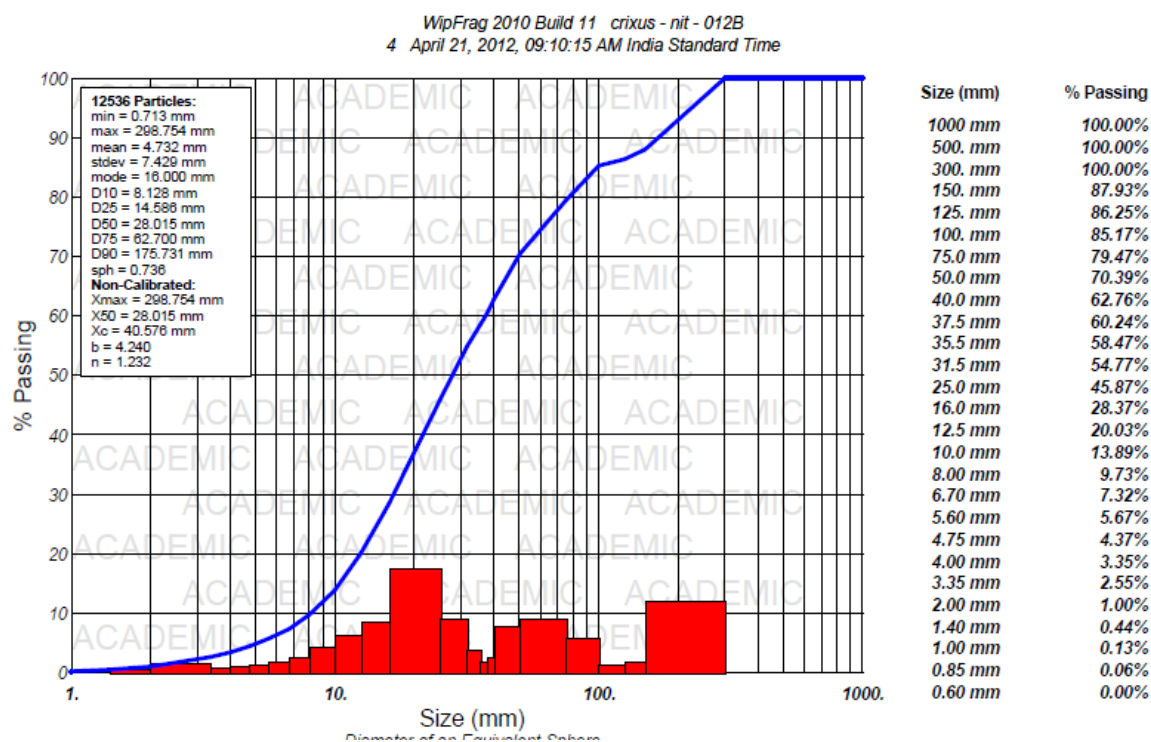


Figure4.8 Size distribution obtained from rock pile sample 4



Figure4.9 Photograph of rock pile sample5

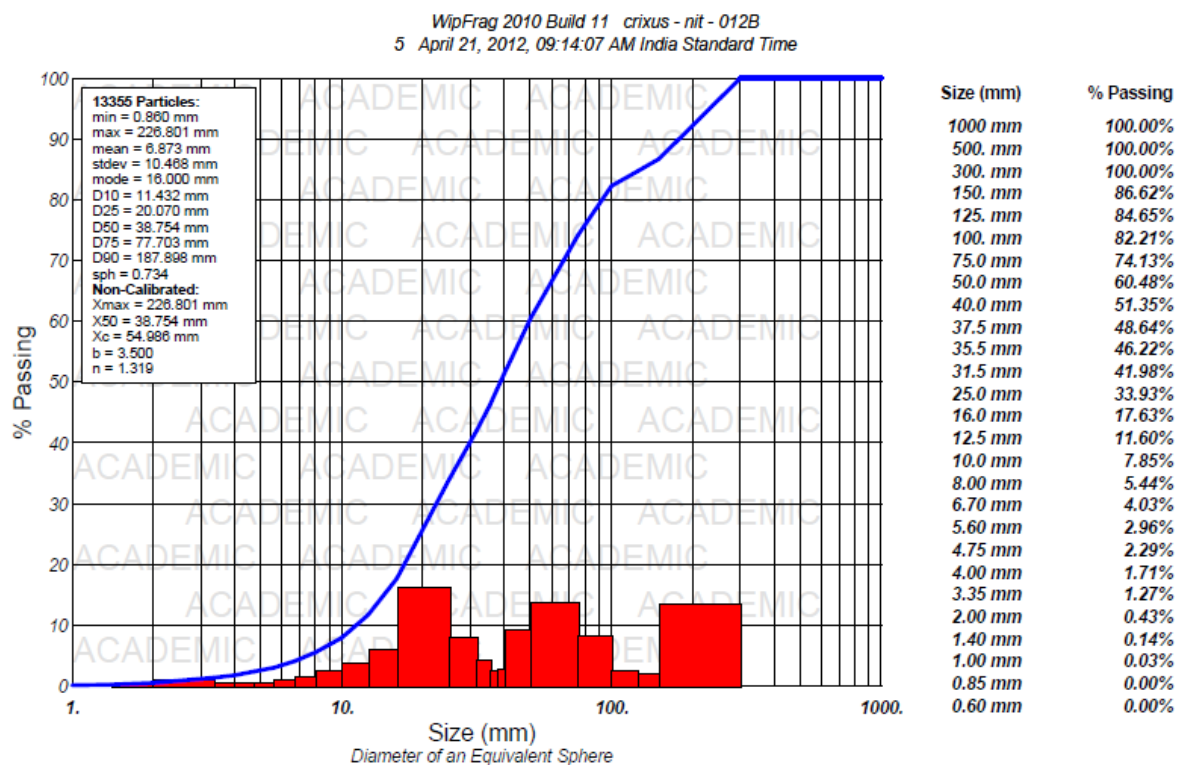


Figure4.10 Size distribution obtained from rock pile sample 5.



Figure4.11 Photograph of rock pile sample6

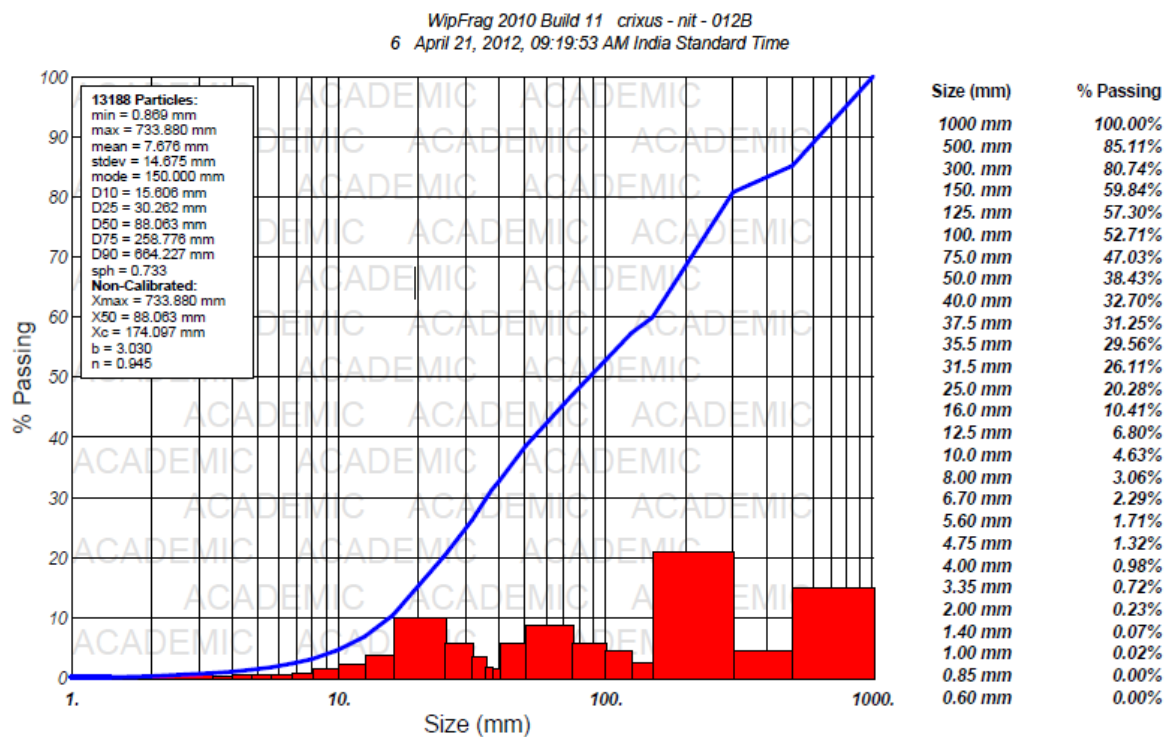


Figure4.12 Size distribution obtained from rock pile sample 6



Figure4.13 Photograph of rock pile sample7

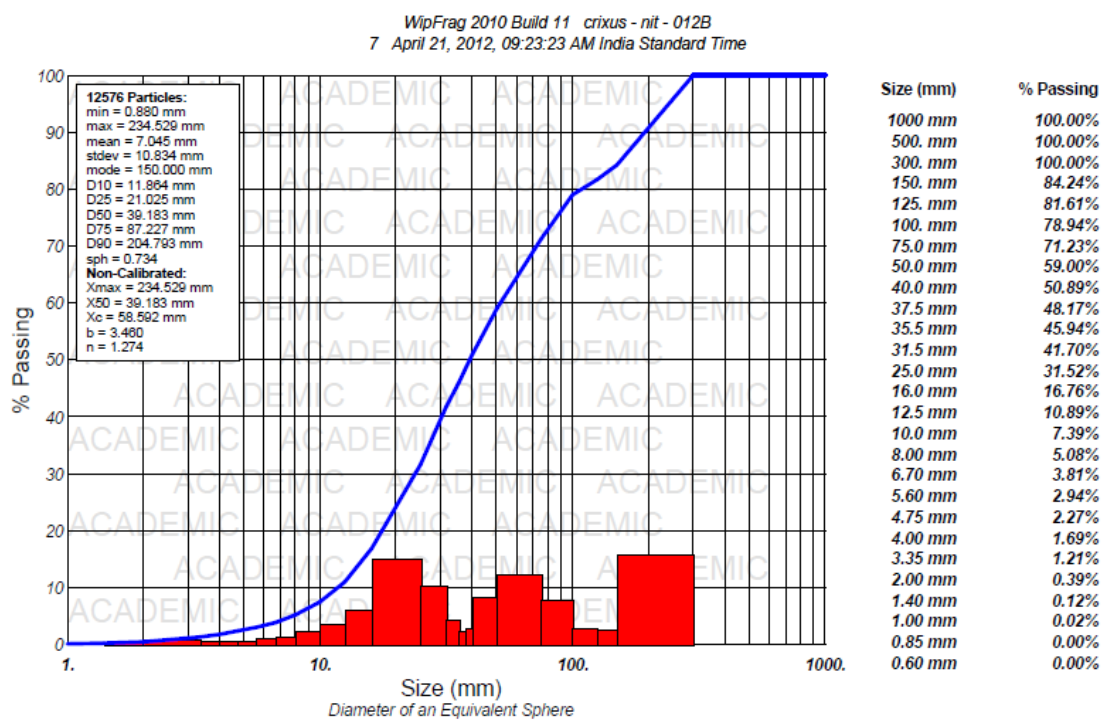


Figure4.14 Size distribution obtained from rock pile sample 7



Figure4.15 Photograph of rock pile sample8

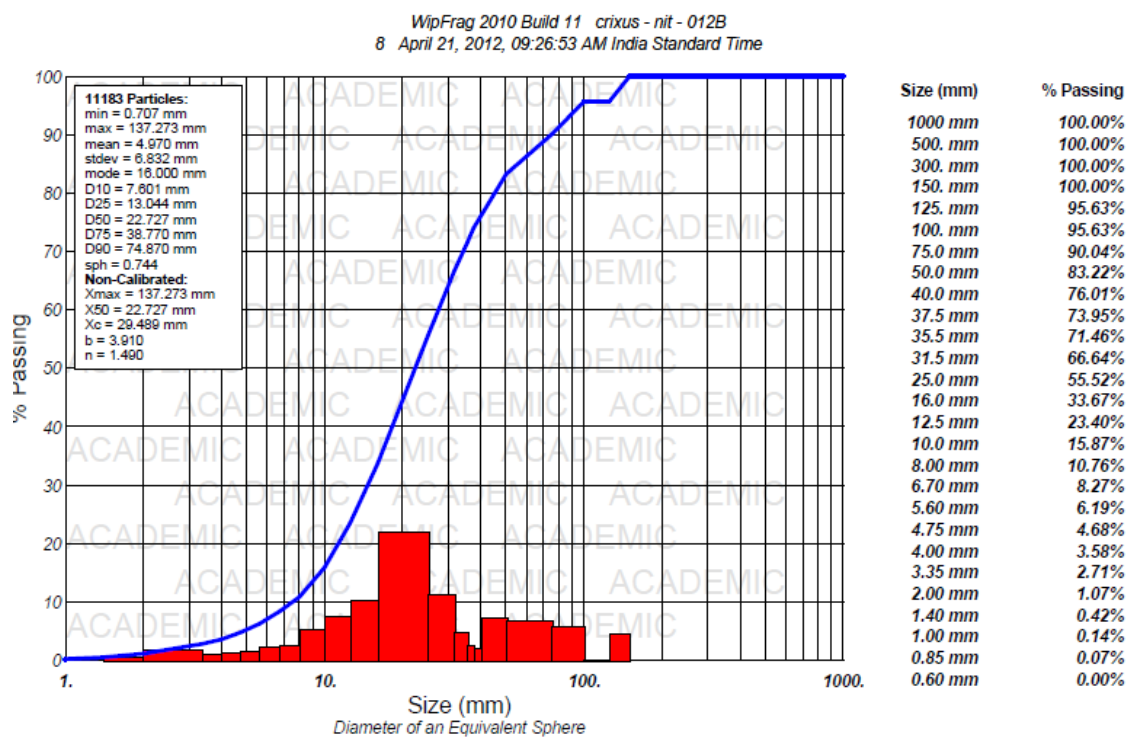


Figure4.16 Size distribution obtained from rock pile sample 8



Figure4.17 Photograph of rock pile sample9

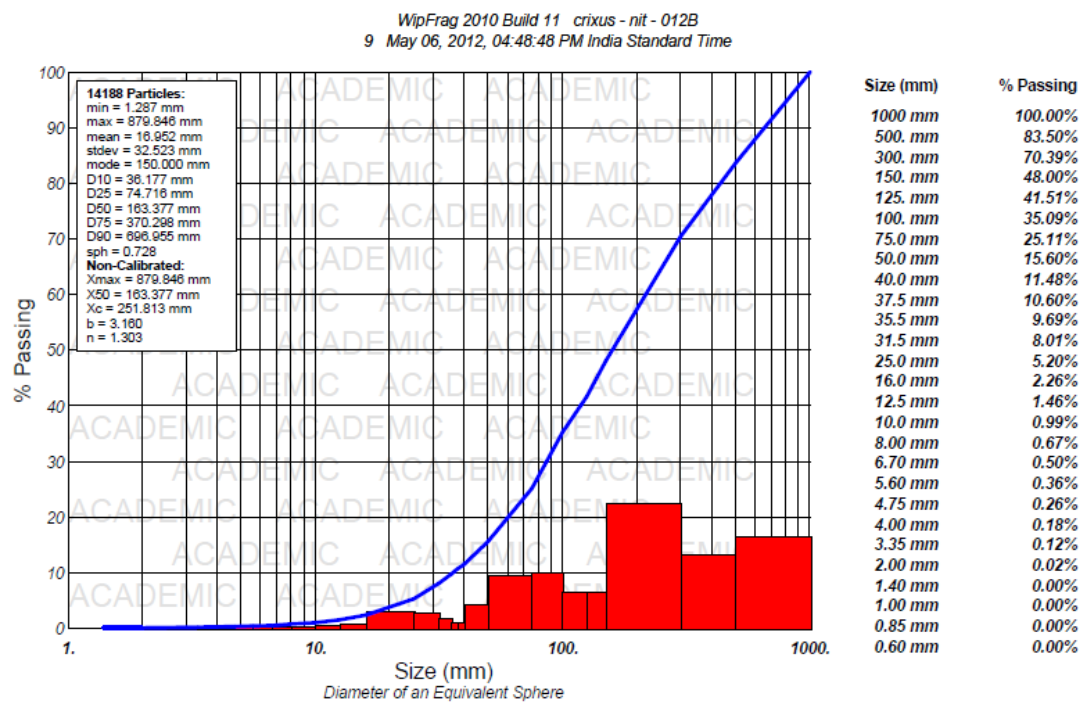


Figure4.18 Size distribution obtained from rock pile sample 9



Figure4.19 Photograph of rock pile sample10.

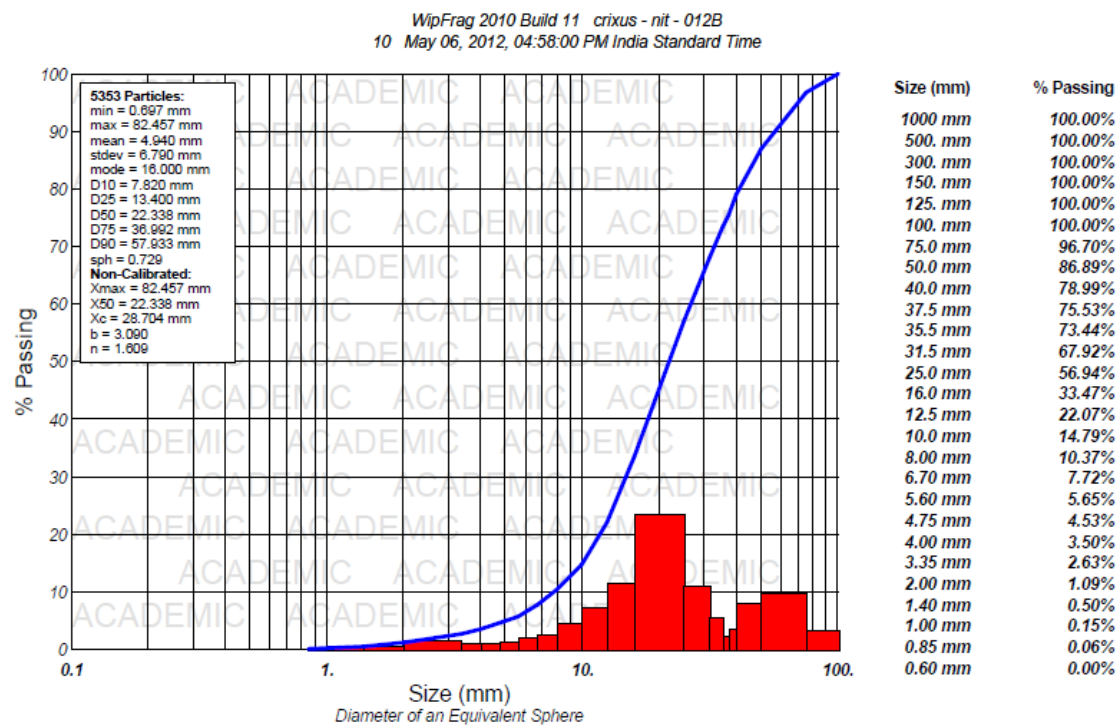


Figure4.20 Size distribution obtained from rock pile sample 10.

4.2 MERGED IMAGE ANALYSIS

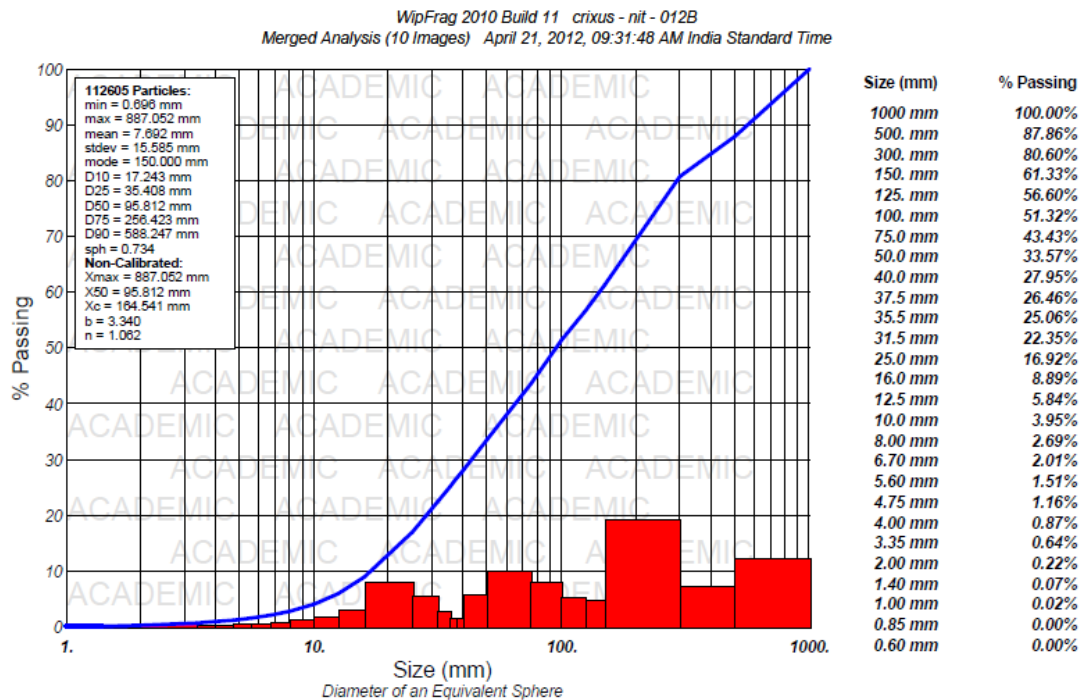


Figure4.21 Size distribution obtained from merged analysis of the 10 samples.

It was observed that maximum percentage at 47.37 % of material lie between 10 to 100mm followed by material sizes between 100mm to 500mm at 36.54%.

It is also found that

$D_{10}=17.243\text{mm}$

$D_{90}=588.247\text{mm}$

$X_C=164.541\text{mm}$

Where the notations are described earlier.

The results obtained from merged analysis are shown below.

Multiple image analysis results	Size distribution (%)			
	500-1000mm	100-500mm	10-100mm	0-10mm
	12.14	36.54	47.37	3.95

Table 4.1

4.3 CALCULATION OF UNIFORMITY COEFFICIENT AND COEFFICIENT OF CURVATURE

4.3.1 Uniformity Coefficient C_u (measure of the particle size range)

C_u is also called Hazen Coefficient. Hazen found that the sizes smaller than the effective size affected the functioning of filters more than did the remaining 90 percent of the sizes. To determine whether a material is uniformly graded or well graded he proposed the following

$$C_u = D_{60} / D_{10}$$

$C_u < 5$ ----- Very Uniform

$C_u = 5-15$ ----- Medium Uniform

$C_u > 15$ ----- Non uniform

From the above merged analysis graph (fig 4.21), we found that $D_{60} = 149\text{mm}$

$$D_{10} = 17.243\text{mm}$$

$$\text{Hence } C_u = 149 / 17.243 = 8.64$$

So it shows that the size distribution is non-uniform.

4.3.2 Coefficient of Gradation or Coefficient of Curvature C_g

(Measure of the shape of the particle size curve)

$$C_g = (D_{30})^2 / (D_{60} \times D_{10})$$

C_g from 1 to 3 shows the distribution is well graded or desired sizes.

From the merged analysis graph it is found that $D_{30} = 45\text{mm}$

Putting the value of $D_{60} = 149\text{mm}$, $D_{10} = 17.243\text{mm}$ and $D_{30} = 45\text{mm}$ in the above given formulae we get the value of $C_g = 0.79$ which is less than 1.

So the distribution is poor graded.

CHAPTER-5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSIONS

The investigation was carried out to evaluate the efficiency of blasting process of the target mine. The images taken were only ten. The analysis was based on those ten images. Both single and merged image analysis were carried out. The following conclusions are drawn from the analysis.

- The optimum size distribution of the 10 samples with merged analysis contain the size
 - Between 500-1000mm:12.14%
 - Between 100-500mm:36.54%
 - Between 10-100mm:47.37%
 - Less than 10mm:3.95%

The blasted pile contained maximum percentage of material in the size range 10 to 100mm with a percentage of 47.37 followed by between 100 to 500mm with a percentage of 36.54.

- The coefficient of curvature is less than 1 thus classifying that the distribution is not well graded.
- The WipFrag system is less time consuming analysis method than the traditional approaches as sieving with a better accuracy. Multiple images can be analysed individually as well in combined form.

5.2 RECOMMENDATION FOR FURTHER RESEARCH

This investigation was undertaken as a part of final year project with a fixed time limit. Hence many aspects of fragmentation could not be investigated. In future research may be carried out by considering more blasting parameters as well as by analysing more images for better understanding of the subject in detail.

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